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THE SEASONING AND PRESERVATIVE TREATMENT OF HEMLOCK AND TAMARACK CROSS-TIES.

By

W. F. SHERFESEE,
FOREST ASSISTANT.

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THE SEASONING AND PRESERVATIVE TREATMENT OF HEMLOCK AND TAMARACK CROSS-TIES.

INTRODUCTION.

Timber values have been increasing so rapidly during the last few years that many railroads have found it necessary to completely change their timber policy. White oak, which formerly made up a large part of the tie timber of the United States, has become so scarce that it is being replaced to an ever-increasing extent by cheaper and more abundant woods. The kinds of timber used as substitutes naturally vary with different sections of the country. The kinds chiefly used in the northern Lake States are cedar, hemlock, and tamarack.

When oak first ceased to be used extensively for ties in that section of the country arborvitæ, or Michigan cedar, was resorted to as a substitute. But, like oak, arborvitæ has also had enormous demands made upon its limited supply, and most of this timber is now being made into telephone and telegraph poles. Hence the railroads were compelled a second time to resort to some other wood, and hemlock and tamarack now make up the bulk of the tie timber. Since these are found in the Lake States in large quantities, they may be expected to furnish an important source of the future tie supply of the region.

Of the total number of ties purchased by the railroads of the United States in 1905 tamarack furnished 3,060,082, or 4 per cent, and hemlock 1,713,090, or about 2.2 per cent. Of the tamarack ties 99.1 per cent were produced in the Lake States, and of the hemlock 93.4 per cent. The specifications of the railroads demand pole ties—that is, the ties are cut from trees large enough to permit only one tie to be made from a section. Hence heartwood is exposed on the faces of the tie, while the rounded sides have a layer of sapwood. The ties are 8 feet long, with sawed ends. The depth between the faces must be uniformly 6 or 7 inches, and each face must be at least 6 or 7 inches wide at the narrowest point. Cutting and hewing generally begin in September and continue until the last of March. The hauling season opens about the first of January and closes about the first of April. The ties are then corded along the right of way to await shipment to their destination.

Hemlock and tamarack ties last only about five years. Hence in order to derive the greatest service it is necessary to treat them with some preservative, and zinc-chlorid is most commonly employed. For this purpose the Chicago and Northwestern Railway Company erected a treating plant at Escanaba, Mich., in 1903. Previous to that time very little hemlock and tamarack had been treated. Both are unusually difficult to impregnate, because of the density of their wood; and the best method of handling had not been determined. It was even contended that the resistant character of the wood made all forms of preservative treatment impracticable. In the spring of 1905 a cooperative experiment was undertaken by the Forest Service and the Chicago and Northwestern Railway Company, in order to find out what results were being obtained at the Escanaba plant, and, if possible, to devise methods for bettering the treatment. Preliminary experiments and analyses of treated ties of both species showed that the wood failed to absorb the desired amount of the preservative and that most of the absorption was confined to a narrow exterior layer.

SOURCE OF MATERIAL.

According to the original plan, 250 ties of each species were to be cut and delivered at the treating yard each month for one year. But owing to the fact that logging is difficult in tamarack swamps in the summer the tamarack was all cut during the winter, and the heavy snows of winter made slight modifications necessary in the hemlock supply. However, during December and January, 1905–6, 688 hemlock ties were secured, and since tamarack is not cut for commercial purposes during the summer it was considered impracticable to include summer-cut tamarack in the experiment.

The total number of ties secured was 8,214, of which 4,574 were hemlock and 3,640 tamarack. These were secured from three different sources:[a] (1) 3,547 cut and received in monthly allotments in 1905–6; (2) 100 cut in the winter of 1903–4 and taken from a raft which had been in the water from six to eight weeks; (3) 4,567 cut during the winter of 1905–6 and reserved from the supply in the yard, where they had been received in April. In order to show the best method of handling, these ties were redistributed into smaller lots or classes, so that each would receive the same treatment from the time of cutting up to the time of the completion of the experiment Some were peeled at the time of cutting, others were allowed to season without removing the bark, and still others were subjected to various conditions of soaking.

[a] These three sources will be referred to hereafter as lot 1, lot 2, and lot 3.

SEASONING.[a]

FORMS OF PILING TIES.

At the treating yard all ties were piled in isolated groups, with tiers arranged on three different plans—7 by 7 ties, 7 by 2, and 8 by 1.

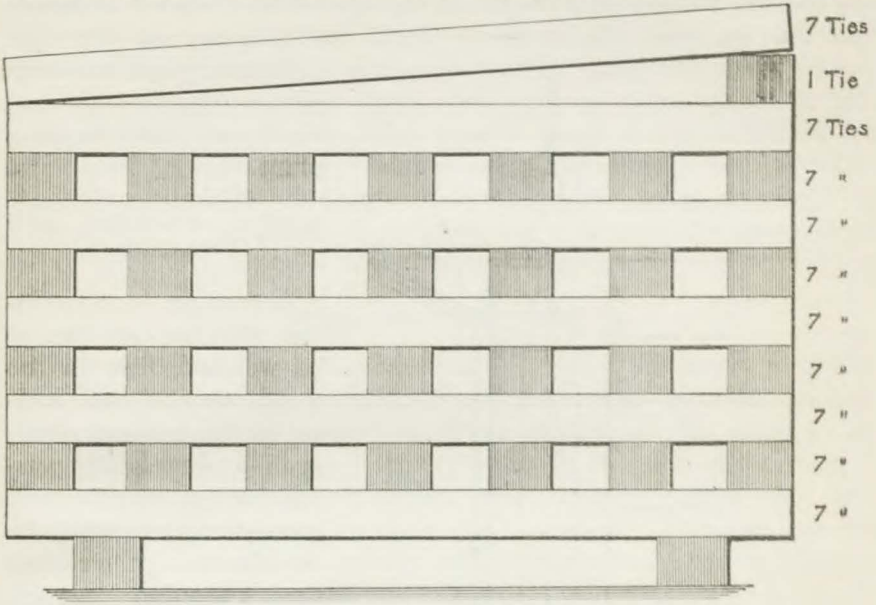

FIG. 1.—A 7 by 7 tie pile.

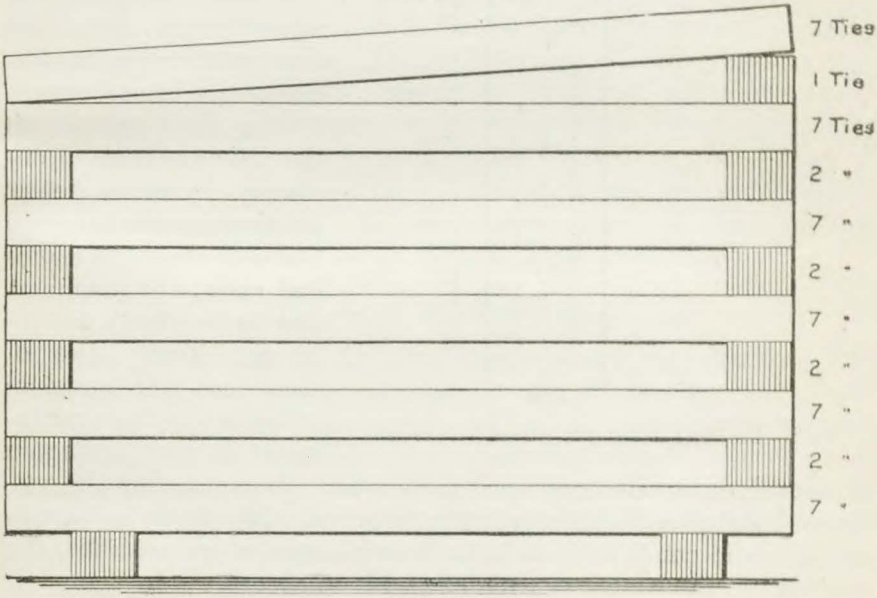

FIG. 2.—A 7 by 2 tie pile.

[a] The methods and results of the seasoning experiments of lot 3 are here included through the courtesy of the superintendent of the Escanaba treating plant.

In the ordinary seasoning yard, where economy of space and labor require that the piles shall be close together and that there shall be about twenty tiers to each pile, the conditions are wholly different. The circulation of the air is largely shut off from the interior piles, and the sun reaches only the ties in the upper tiers; hence it is important that an open pile be used. The 7 by 2 pile proved the most satisfactory and has been adopted by the management of the treating plant.

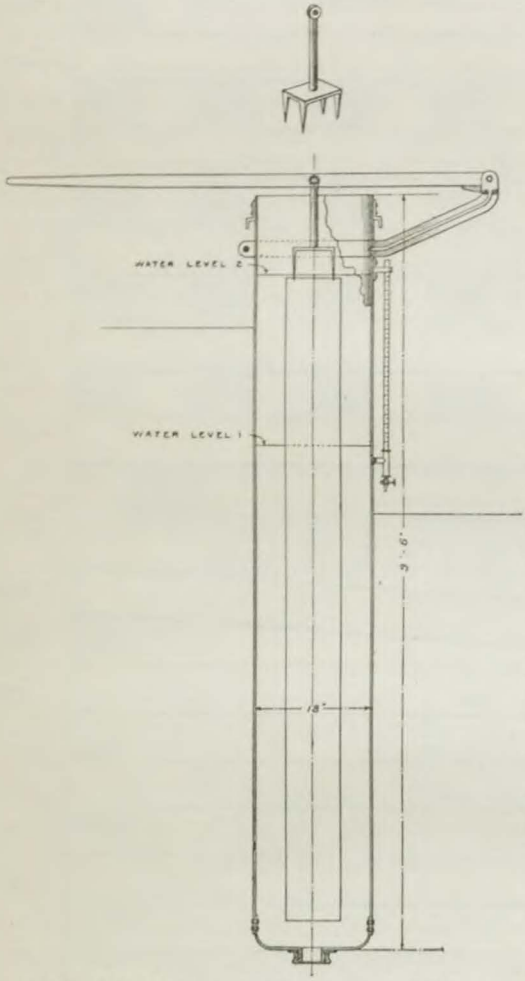

FIG. 3.—A tank for obtaining the volume of cross-ties.

TAKING WEIGHTS AND VOLUMES.

According to the original plan the ties were to be weighed first in the woods, then at their arrival at the treating plant, again at fortnightly periods for two months, and thereafter at monthly intervals during the rest of the seasoning period. Although this plan was adhered to as closely as was practicable, modifications were necessary. During the winter, when the temperature constantly remained below the freezing point and the ties were covered with ice and snow, the weighings had to be wholly discontinued. Thirty ties of each class were weighed immediately upon arriving at the yard and again at monthly intervals from April to October. In comparing the successive weights certain irregularities occurred, due chiefly to temporary climatic conditions, such as heavy rains, which retarded the seasoning of the timber or even caused it to absorb water.

The average weight per cubic foot for each class of material was obtained for the successive weighing periods by dividing the weight

of the ties by their volume. The volume varied greatly, and as the ties were decidedly irregular in shape it had to be determined by means of a xylometer for taking volume measurements. (See fig. 3.) This is an iron tank 9 ½ feet high and 18 inches wide, which is about three-fourths filled with water. Attached to the upper portion is a vertical glass gauge about 42 inches long, graduated so that any variation in the height of the water is read off in hundredths of a cubic foot. A sufficient number of ties were received to permit the results to be accurately applied to each class of material represented in the experiments. Most of the volumes were determined while the wood was green, but as the shrinkage which takes place during air seasoning is negligible, for all practical purposes the volume of the green wood can be applied to the ties at all stages of seasoning.

SEASONING INFLUENCES.

The rate of seasoning is influenced chiefly by the structure of the wood and by climatic conditions. A wood may be open-grained and porous, and thus permit rapid evaporation of the water in its cells, or it may be dense and impervious. In this first class are such quick-seasoning species as loblolly pine, western yellow pine, and arborvitæ; in the second, hemlock and tamarack. The close-grained structure of both of these greatly retard evaporation, and in hemlock especially there is a tendency to season only in a thin and irregular surface layer, which thus forms a protective covering over the interior wood. Climatic conditions in the northern peninsula of Michigan are somewhat unfavorable. During five months of the year, November to March, the average temperature is almost constantly below the freezing point. Furthermore, during practically the entire winter the ground is covered with snow, which by melting retards loss of moisture from the wood during the periods when the temperature is above the freezing point. In this climate, therefore, the seasoning period is limited to about seven months, April to October.

THE RATE OF SEASONING.

In the experiments on treating it was found that hemlock and tamarack ties can be successfully treated when they have been reduced in weight by seasoning to 40 and 42 pounds, respectively. The objects of the experiments in seasoning were to find the best methods of handling the ties so as to bring them to this condition and to see what influence various methods of seasoning might have upon the absorptive qualities of the timber.

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THE RATE OF SEASONING OF HEMLOCK TIES.

In the following discussion of the hemlock ties those peeled at the time of their arrival at the yard and piled in the 7 by 2 form will be taken as a basis for comparison. The rate of seasoning shown by the ties cut from June to September is rapid up to the latter part of October; in November a sharp decrease occurs, and during the winter months, from December to April, the loss in weight is slight. (See Table 1.) Beginning with an average green weight of about 56 pounds per cubic foot, the June ties reached a weight of 39.5 pounds by the 1st of November, and at the same time the July ties weighed 41.2 pounds, the August ties 42.1 pounds, and the September ties 44.1 pounds per cubic foot. During the winter months very little moisture was lost, but with the approach of warmer weather in April seasoning was resumed, which resulted in an additional loss of from 3 to 5 pounds per cubic foot by the 1st of August. By this time the October and December ties weighed, respectively, 38.2 and 39 pounds per cubic foot.

TABLE 1.—*Rate of seasoning for hewed hemlock ties cut in different months of the year, peeled on their arrival at the treating yard, and piled 7 by 2.*

Time seasoned.	June cut.		July cut.		August cut.		September cut.		October cut.		December cut.	
	Moisture content in dry weight.	Weight per cubic foot.	Moisture content in dry weight.	Weight per cubic foot.	Moisture content in dry weight.	Weight per cubic foot.	Moisture content in dry weight.	Weight per cubic foot.	Moisture content in dry weight.	Weight per cubic foot.	Moisture content in dry weight.	Weight per cubic foot.
	Per ct.	*Lbs.*	*Per ct.*	*Lbs.*	*Per ct.*	*Lbs.*	*Per ct.*	*Lbs.*	*Per ct.*	*Lbs.*	*Per ct.*	*Lbs.*
0	138.5	57.2	135.5	56.5	131.9	55.7	131.0	55.4	130.3	55.3	129.3	55.0
30	102.0	48.5	99.8	48.0	100.0	48.0	97.0	47.3	116.0	51.8	126.3	54.3
60	82.2	43.7	83.7	44.1	82.0	43.7	83.7	44.1	103.3	48.8	123.0	53.5
90	72.7	41.4	75.7	42.2	75.3	42.1	79.8	43.2	95.9	47.0	119.4	52.7
120	67.0	40.1	71.7	41.2	71.8	41.2	78.6	42.9	91.0	45.8	114.1	51.4
150	64.5	39.5	69.3	40.6	69.2	40.6	77.8	42.7	87.3	45.0	104.0	49.0
180	64.0	39.4	68.3	40.4	67.1	40.1	76.3	42.3	84.0	44.2	84.9	44.4
210	63.0	39.1	67.4	40.2	65.1	39.6	74.0	41.8	80.0	43.2	70.0	40.8
240	61.3	38.7	66.2	39.9	62.8	39.1	70.5	40.9	74.2	41.8	62.3	39.0
270	59.1	38.2	64.5	39.5	59.5	38.3	65.0	39.6	66.9	40.1	.....	.....
300	56.8	37.6	61.9	38.9	54.8	37.2	58.5	38.0	59.1	38.2	.....	.....
330	54.3	37.0	58.5	38.0	49.2	35.8	52.4	36.6	.....	.....	.....	.....
360	51.2	36.3	54.3	37.0	44.0	34.6	.....	.....	.....	.....	.....	.....
390	47.5	35.4	49.8	36.0	.....	.....	.....	.....	.....	.....	.....	.....
420	44.0	34.6	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....

NOTE.—The oven-dry weight of hemlock is 24 pounds per cubic foot. Because of certain irregularities shown by the November ties, they have been omitted from the above table.

It should be borne in mind that these ties were stacked in isolated piles, exposed to the full influences of sun and wind. However, the ties of lot 3 were reserved by the superintendent of the treating plant from the ordinary run of ties supplied to the yard, and were stacked in 7 by 2 forms surrounded by other piles, and hence may fairly be taken to represent average commercial conditions. These ties were cut during the winter of 1905–6, probably in January, and were brought to the yard in April.

TABLE 2.—*Rate of seasoning for peeled hemlock ties reserved by the superintendent of the treating plant.* (*Lot 3.*)

Date of weighing.	Time seasoned from first weighing.	Moisture content of dry weight.	Average weight per cubic foot.
	Days.	*Per cent.*	*Pounds.*
April 13	0	129	55.0
May 13	30	95	46.8
June 13	60	82	43.7
July 13	90	72	41.3
August 13	120	65	39.6
September 13	150	60	38.4
October 13	180	56	37.4
November 3	201	53	36.8

Assuming an average green weight of about 56 pounds per cubic foot, the weight shown by the experimental ties, the first weighing in April indicates a loss of only 1 to 2 pounds per cubic foot, thus showing that the winter-cut ties brought to the yard in the early spring do not season materially in the woods or in transit to the treating plant. During the first month of seasoning the ties lost 8.2 pounds per cubic foot, by the middle of August 15.4 pounds, and by November 18.2 pounds, a reduction of weight to 36.8 pounds in seven months.

Among the ties of lot 3 were 1,158 hemlock ties, which were allowed to season without removing the bark. A comparison of the successive weights of peeled and unpeeled ties indicates that peeling tends to more than double the rate of seasoning for the first thirty days; the rate then gradually lessens for the next two months, when both have practically the same rate, and that this rate then continues to the end of the seasoning period. In November 100 of the unpeeled ties were peeled and measured, and it was found that they weighed 40.9 pounds per cubic foot as compared with 36.8 pounds, the weight of the ties which had been seasoned without the bark.

Winter-cut ties brought to the treating plant in early spring and piled 7 by 2, peeled or unpeeled, will be ready to treat by late summer or fall. But if transportation to the yard is delayed it will, in most cases, be necessary to hold the ties until the following summer. Yet if ties were stacked in open piles along the right of way as soon

as they are hauled from the woods a delay in transporting them to the treating yard would be of little importance. However, in only a few cases will it be possible to make the necessary arrangements for proper piling, and for this reason it is recommended that all ties should be carried to the treating yard and stacked in loose piles as early in the spring as possible.

THE RATE OF SEASONING OF TAMARACK TIES.

The tamarack ties which form the basis of Table 3 are from lots 1 and 3, and were cut in the winter of 1905–6 and brought to the treating plant and peeled during the latter part of the following April. The ties of lot 1 at that time averaged 49.7 pounds per cubic foot. Table 3 shows that a heavy moisture loss occurred during the first sixty days of seasoning, reducing the weight per cubic foot to 42.7 pounds. By the latter part of July the ties weighed only 41.6 pounds per cubic foot, making a total loss of 8.1 pounds in three months. During the remaining summer and fall the rate of seasoning was slow.

TABLE 3.—*Rate of seasoning for peeled tamarack ties.*

Ties of lot 1 piled 7 by 2.			Ties of lot 3 piled 7 by 2.		
Time seasoned.	Moisture content in per cent of dry weight.	Average weight per cubic foot.	Time of seasoning from first weighing.	Moisture content in per cent of dry weight.	Average weight per cubic foot.
Days.	*Per cent.*	*Pounds.*	*Days.*	*Per cent.*	*Pounds.*
0	62.5	49.7	0	59	48.7
30	47.3	45.1	30	41	43.1
60	39.7	42.7	60	35	41.3
90	36.0	41.6	90	32	40.4
.....	.....	.....	120	31	40.1
.....	.....	.....	150	30	39.8
.....	.....	.....	180	29	39.5
.....	.....	.....	201	38	41.8

NOTE.—The oven-dry weight of tamarack is 30.6 pounds per cubic foot.

The peeled tamarack ties from lot 3 showed a similar rate of seasoning. They were cut, brought to the yard, and first weighed at about the same time as lot 1. During the first month they lost 5.6 pounds per cubic foot and by the end of July weighed 40.4 pounds per cubic foot. Thereafter the loss in weight was slight. In the following November the weight had risen to 41.8 pounds, the increase of 1.4 pounds per cubic foot since the latter part of July being probably due to a slight absorption of moisture during the rainy days which preceded the November weighing. One hundred ties which had been seasoned without removing the bark were peeled and measured at the same time. Their weight was found to be 41.4 pounds per cubic foot, or four-tenths of a pound less than the peeled ties.

It will thus be found that for loosely piled tamarack ties an exposure to summer weather of from three to four months is sufficient before treatment.

A comparison between the rates of seasoning of peeled and unpeeled ties shows the difference in tamarack to be much less marked than in hemlock. This is doubtless due to the fact that tamarack bark is much thinner than that of hemlock and during the seasoning period is more or less undermined by beetles.

THE RESULT OF SEASONING FOR MORE THAN ONE YEAR.

Near the close of the experimental work at Escanaba, weights and volumes were taken on a number of hemlock and tamarack ties which had been cut in the winter of 1903–4 and consequently had passed through two full seasoning periods. The hemlock ties weighed 30.6 pounds per cubic foot and the tamarack ties 39 pounds. The corresponding moisture contents are 6.6 pounds per cubic foot for hemlock and 8.4 pounds for tamarack, or, in per cent of the dry weight, they are 27.5 per cent for both species. At the time the last weights were taken the hemlock ties were still seasoning at a low rate, while the weights of the tamarack ties were stationary. Hence it is probable that, in time, the percentage of moisture in the hemlock ties would have fallen slightly below that of tamarack. On the other hand, tamarack loses by far the greatest amount of its moisture during the first three months of seasoning and soon reaches practically as low a moisture content as can be attained by air drying.

THE AIR-DRY WEIGHT OF HEMLOCK.

In order to ascertain the lowest moisture content which hemlock can be made to reach by air seasoning, sections 3 inches thick were sawed from timber cut for ties during seven months of the year. After their volume had been determined the sections were stored in a dry room to season. Weighings were made daily for five days and then at weekly intervals until the wood approached an air-dry condition. The final weight per cubic foot averaged 27.7 pounds, the weights for the individual sections varying from 26.3 pounds to 28.8 pounds per cubic foot. By comparing these figures with the oven-dry weight of hemlock,[a] which is 24 pounds per cubic foot, it is found that the moisture content of the sections varied from 12.8 to 20.2 per cent of their dry weight, with an average of 15.4 per cent.

[a] The result of drying the wood to a constant weight at 100° C. The corresponding weight of tamarack is 30.6 pounds per cubic foot.

It should be realized, of course, that these figures are merely comparative, and can never be reached by timber in the form of ties and exposed to the moisture of the open air.

TREATING.

Because of the many points on which information was desired and the comparatively limited supply of material available it was impossible to work with only one variable at a time. However, in order to avoid confusion in presenting the conclusions excerpts have been made of all data which bear upon the point in question.

THE EFFECT OF AIR SEASONING BEFORE TREATMENT.

This may be expected to manifest itself in two general ways—first, in the amount of the preservative absorbed by the timber and, second, in the diffusion of the preservative throughout the interior of the wood. The diffusion may take place while the preservative is being injected, or through osmotic and capillary forces during the seasoning of the timber after treatment. These points will be considered separately.

ABSORPTION OF THE PRESERVATIVE.

In July, 1905, two tramloads of mixed hemlock and tamarack were included in a regular run at the treating plant. Tramload No. 1 was made up of ties from lot 1, which had been seasoned four months without removing the bark. Tramload No. 2 was composed of ties from lot 2, which had been soaked for six or eight weeks, and then seasoned for twelve months with the bark and for an additional two months after it had been removed. Each tie in the two loads was weighed before and after treating and again at intervals of five hours, and five, forty-two, sixty-nine, and one hundred and six days after treatment. Table 4 shows the weight before and after treatment and the gain in pounds and in per cent due to treatment.

TABLE 4.—*Absorption of preservative by hemlock and tamarack ties, with gain or loss of the weight before treatment due to seasoning for one hundred and six days after impregnation.*

[H=Hemlock. T=Tamarack.]

Tie No.	Tramload No. 1.						Tramload No. 2.					
	Weight before treatment.	Weight after treatment.	Gain during treatment.		Decrease in weight before treatment from that after 106 days' seasoning.[a]	Kind of timber.	Weight before treatment.	Weight after treatment.	Gain during treatment.		Increase in weight before treatment from that after 106 days' seasoning.[a]	Kind of timber.
	Lbs.	*Lbs.*	*Lbs.*	*P. ct.*	*Lbs.*		*Lbs.*	*Lbs.*	*Lbs.*	*P. ct.*	*Lbs.*	
1	149.5	184.0	34.5	23.1	9.0	H	156.0	199.0	43.0	27.6	1.5	H
2	131.0	165.0	34.0	26.0	4.0	H	134.0	184.5	50.5	37.7	7.5	H
3	150.0	163.0	13.0	8.7	40.5	H	233.5	286.5	53.0	22.7	3.5	T
4	188.0	224.0	36.0	19.2	14.5	T	111.0	145.5	34.5	31.1	[c].5	T
5	164.0	183.5	19.5	11.9	29.5	H	143.0	183.5	40.5	28.3	[c]1.5	T
6	175.0	197.0	22.0	11.3	41.5	H	169.5	211.0	41.5	24.5	1.0	T
7	148.5	186.5	38.0	25.6	10.5	T	169.0	206.0	31.0	18.3	3.5	T
8	161.0	199.5	38.5	23.9	5.0	H	159.5	195.5	36.0	22.6	2.5	T
9	216.5	241.0	24.5	11.3	24.0	T	156.5	218.5	62.0	39.6	12.5	T
10	244.5	320.5	76.0	31.1	[b]9.5	T	192.0	241.5	49.5	25.8	3.5	T
11	258.0	284.5	26.5	10.3	21.0	T	154.0	198.0	44.0	28.6	.5	T
12	150.5	192.0	41.5	27.6	6.5	T	131.0	176.0	45.0	34.3	3.5	T
13	129.0	151.0	22.0	17.1	37.5	H	152.0	201.5	49.5	32.6	3.0	T
14	160.0	177.0	17.0	10.6	51.0	H	112.5	169.5	57.0	50.7	[c]1.0	T
15	141.5	187.0	45.5	32.2	7.5	T	100.0	136.5	36.5	36.5	[c]2.5	T
16	181.5	211.0	29.5	16.2	16.0	T	129.5	180.0	50.5	39.0	14.0	T
17	207.5	235.0	27.5	13.3	43.0	H	230.5	281.0	50.5	21.9	5.5	T
18	132.5	156.0	23.5	17.7	20.0	T	114.5	144.0	29.5	25.8	1.0	T
19	129.0	150.5	21.5	16.7	23.5	H	119.0	160.0	41.0	34.5	3.0	T
20	143.5	170.5	27.0	18.8	13.0	T	122.0	177.0	55.0	45.1	4.5	T
21	140.5	154.0	13.5	9.6	37.0	H	125.5	166.5	41.0	32.7	4.5	T
22	175.5	212.5	37.0	21.1	33.0	H	135.5	192.0	56.5	41.7	4.5	T
23	162.0	180.0	18.0	11.1	52.0	H	160.5	199.5	39.0	24.5	1.0	T
24	114.5	141.5	27.0	23.7	7.0	T	117.0	143.5	26.5	22.7	1.5	T
25	212.0	229.5	17.5	8.2	35.5	T	164.0	207.0	43.0	26.2	[c]2.0	H
26	219.5	243.0	23.5	10.7	41.5	H	102.5	136.0	33.5	32.7	1.0	H
27	179.5	212.5	33.0	18.4	36.0	H	.....	.....	.....	.....	.....	.....
28	188.0	213.0	25.0	13.3	43.5	H	.....	.....	.....	.....	.....	.....
Average	.....	.....	.....	16.8	.....	.....	.....	.....	.....	31.1	.....	.....

[a] This column represents the decrease or increase between the weight before treatment and the weight in one hundred and six days of seasoning after treatment.
[b] Gain.
[c] Loss.

The main points to be noted in Table 4 are:

(1) The wide variation and low average in the absorption of the preservative by the ties in tramload No. 1.

(2) The comparative uniformity and high average of the absorption of the preservative by the ties in tramload No. 2.

(3) The great amount of water, in excess of that taken on during treatment, lost in subsequent seasoning of the ties in tramload No. 1 as compared with the ties in tramload No. 2.

(4) That the ties which gain least during treatment show the heaviest loss in the subsequent seasoning, thus giving evidence of their relatively greater moisture content before treatment.

Table 5 shows the weights before and after treatment; the gain in pounds and in per cent due to treatment, and the loss in pounds,

in per cent, and in per cent of gain at different periods during the one hundred and six days of subsequent seasoning. The figures are based on the average tie in the two tramloads. This table shows very strikingly the importance of thorough seasoning, because in all preservatives composed of soluble salts the more salt up to a certain amount injected into the wood the more lasting will be its benefits.

TABLE 5.—*Absorption in treatment and loss after treatment.*

	Average of tramload—	
	No. 1.	No. 2.
Weight before treating, pounds	167.9	146.4
Weight after treating, pounds	197.1	190.2
Gain during treating, pounds	29.2	43.8
Gain during treating, per cent	[a] 17.4	[a] 29.9
FIVE HOURS AFTER TREATING.		
Loss, pounds	5.2	3.1
Loss, per cent	2.6	1.6
Loss, per cent of gain	17.8	7.1
FIVE DAYS AFTER TREATING.		
Loss, pounds	17.7	15.5
Loss, per cent	9.0	8.1
Loss, per cent of gain	60.6	35.4
FORTY-TWO DAYS AFTER TREATING.		
Loss, pounds	43.5	35.8
Loss, per cent	22.1	18.8
Loss, per cent of gain	149.0	81.7
SIXTY-NINE DAYS AFTER TREATING.		
Loss, pounds	51.2	41.7
Loss, per cent	26.0	21.9
Loss, per cent of gain	175.4	95.2
ONE-HUNDRED AND SIX DAYS AFTER TREATING.		
Loss, pounds	53.3	41.1
Loss, per cent	27.0	21.6
Loss, per cent of gain	182.5	93.9

[a] The slight difference shown in the per cent of gain as compared to that given in Table 1 is due to averaging.

TABLE 6.—*Absorption in relation to weight of wood.*

Weight per cubic foot before treatment.	Percentage of ties absorbing over 10 pounds per cubic foot.		Weight per cubic foot before treatment.	Percentage of ties absorbing over 10 pounds per cubic foot.	
	Hemlock.	Tamarack.		Hemlock.	Tamarack.
Pounds.			*Pounds.*		
57	0	0	41	53	68
56	5	0	40	56	72
55	9	7	39	60	76
54	13	12	38	64	.....
53	16	17	37	68	.....
52	19	21	36	72	.....
51	21	26	35	76	.....
50	24	31	34	80	.....
49	27	36	33	85	.....
48	30	40	32	90	.....
47	33	44	31	94	.....
46	36	48	30	99	.....
45	39	52	29	100	.....
44	42	56	28	100	.....
43	46	60	27	100	.....
42	49	64			

The conclusions to be drawn from the foregoing tables are that the moisture content of the timber has a strong influence on the amount of the preservative which the wood absorbs, and that before a satisfactory treatment can be secured the timber must be approximately air dry. The weight per cubic foot which indicates that this condition has been approached varies with the species and the climatic conditions. However, it is clear that for a climate such as prevails in the northern part of the Lake States hemlock can readily be seasoned down to a weight of 40 pounds and tamarack down to 42 pounds per cubic foot within a year after cutting, and if properly handled, in four or five months.

DIFFUSION OF THE PRESERVATIVE.

SEASONING BEFORE TREATMENT.

Although the success or failure of any treatment is measured primarily by the amount of the preservative absorbed, a factor of scarcely less importance is the extent to which the preservative is diffused throughout the heartwood and sapwood in all portions of the timber. This is especially true in timbers in the form of cross-ties.

The fact that it is the face of the tie which is subjected to spiking and rail-cutting makes it very important that this portion of the tie at least should receive a thorough impregnation with the preservative. The round sides of the tie are protected by a layer of porous sapwood which absorbs the liquid readily, and it often happens that these portions of the tie may be thoroughly saturated while the adjoining heartwood shows no absorption whatever. Hence it is that the absorption of the preservative, considered alone, is not a certain criterion of the success or failure of a particular treatment. It may happen that some ties have a greater proportion of sapwood, or that the sapwood in some ties absorbs more of the preservative per cubic foot than in other ties. However, from the large number of analyses which have been made in connection with the present experiment, it has been established that there is a close relation between the total amount of the absorption and the diffusion of the liquid throughout the interior of the tie. It is only natural to expect that under certain conditions the liquid diffuses more widely throughout the interior of the tie, and that this result can be brought about more rapidly in thoroughly seasoned ties than in those in which the moisture in the wood structure presents a mechanical resistance to the diffusion of the preservative. The analysis of over 100 ties to determine the diffusion of the preservative throughout the interior portions of the timber confirms this theory, proving that in general a given amount of the preservative is more equally distributed in the

ties which had been allowed to become air dry before treatment. This is illustrated in Table 7.

TABLE 7.—*Diffusion of preservative throughout hemlock ties.*

[Amount of zinc chlorid per cubic foot of timber.]

Class of ties.	Section.	Sample 1 inch from surface.	Sample half way between center and surface.	Sample at center.
		Pounds.	*Pounds.*	*Pounds.*
Seasoned 14 months, 2 months with bark off	1 inch from end	1.151	0.584	0.528
	1 foot from end	.407	.259	.325
	2 feet from end	.440	None.	None.
Seasoned 5 months with bark on	1 inch from end	.380	.429	.457
	1 foot from end	.149	Trace.	.154
	2 feet from end	.121	None.	.204

SEASONING AFTER TREATMENT.

The analyses shown in Table 7, as well as most of the other analyses given in this report, were made on sections cut from the ties only a short time after treatment. In order to find out whether any noticeable diffusion takes place by osmosis or capillary attraction after treatment, two treated ties each of hemlock and tamarack were cut in half. One half of each was analyzed immediately after the treatment and the other was allowed to season for several months before being analyzed. The comparative analyses are given in Table 8.

TABLE 8.—*Diffusion of the zinc chlorid at different periods after treatment.*

[Amount of dry zinc chlorid per cubic foot of timber.]

Kind of timber.	Sample.	Section 1 inch from end of tie.	Section 1 foot from end of tie.	Section 2 feet from end of tie.	Section 3 feet from end of tie.	Total.	Average.
		Pounds.	*Pounds.*	*Pounds.*	*Pounds.*	*Pounds.*	*Pounds.*
	IMMEDIATELY AFTER TREATMENT.						
Tamarack	A[1]	1.232	0.507	0.330	0.141	2.210	0.553
	B[2]	.471	.076	.000	.000	.547	.137
	C[3]	.741	.028	.093	.000	.862	.216
	AFTER 3½ MONTHS' SEASONING.						
	A	.520	.220	.180	.090	1.010	.253
	B	.350	.000	.000	.000	.350	.088
	C	.430	.000	.000	.000	.430	.108

[1] One inch from surface of tie.
[2] Half way between center and surface of tie.
[3] At center of tie.

TABLE 8.—*Diffusion of the zinc chlorid at different periods after treatment*—Continued.

Kind of timber.	Sample.	Section 1 inch from end of tie.	Section 1 foot from end of tie.	Section 2 feet from end of tie.	Section 3 feet from end of tie.	Total.	Average.
		Pounds.	*Pounds.*	*Pounds.*	*Pounds.*	*Pounds.*	*Pounds.*
	IMMEDIATELY AFTER TREATMENT.						
Hemlock	A	0.671	0.000	0.000	0.000	0.671	0.168
	B	.390	.000	.000	.000	.390	.098
	C	.534	.000	.000	.000	.534	.134
	AFTER 3½ MONTHS' SEASONING.						
	A	.690	.240	.080	.060	1.070	.098
	B	.450	.000	.000	.000	.450	.113
	C	.620	.000	.050	.070	.740	.185
	IMMEDIATELY AFTER TREATMENT.						
Tamarack	A	.687	.124	.124	.066	1.001	.250
	B	.658	.050	.008	.000	.716	.179
	C	.728	.066	.000	.000	.794	.199
	AFTER 4½ MONTHS' SEASONING.						
	A	.480	.250	.260	.190	1.180	.295
	B	.440	.030	.070	.000	.540	.135
	C	.700	.150	.110	.090	1.050	.263
	IMMEDIATELY AFTER TREATMENT.						
Hemlock	A	.847	.042	.000	.000	.889	.222
	B	.494	.000	.000	.000	.494	.124
	C	.314	.024	.024	.000	.362	.091
	AFTER 4½ MONTHS' SEASONING.						
	A	.500	.150	.180	.170	1.000	.250
	B	.230	.040	.000	.000	.270	.068
	C	.280	.110	.130	.110	.630	.158

A considerable variation is shown in the results of the analyses, but this is hardly greater than was to be expected, even in opposite ends of the same tie. While in many cases the seasoned ends show the presence of a slightly greater amount of zinc chlorid, almost as many analyses point to an opposite condition. This variation is undoubtedly due to the difference in the amount of material originally absorbed by the different parts of the tie, showing that no appreciable diffusion takes place after treatment.

THE EFFECT OF PEELING TIES BEFORE SEASONING.

With the exception of the comparatively small number of hemlock ties which are peeled in the woods, all ties for commercial treat-

ment are brought to the treating plant before their bark has been removed. In this condition they are piled to season, and the bark is not taken off until they are ready for treatment. To peel the ties before seasoning involves an additional expense of about 2 cents per tie. In order to find out whether this expense is justified, a comparison was made between peeled and unpeeled ties of both hemlock and tamarack. During the seasoning period it was found that the peeled hemlock ties lost moisture more rapidly than those not peeled, and at the end of October weighed 36.8 pounds per cubic foot as compared with 40.9 for the unpeeled ties. Peeled tamarack, on the other hand, was slightly heavier before treatment than were the unpeeled ties.

We should expect the dryer condition of the peeled[a] hemlock ties to induce a greater absorption of the preservative, but this was contradicted by the results shown in the following table:

TABLE 9.—*Effect of peeling ties before seasoning.*

[Average of cylinder loads; pounds per cubic foot.]

Run No.	Class of timber.	Absorption.		Difference in favor of unpeeled ties.	Weight before treatment.	
		Peeled.	Unpeeled.		Peeled.	Unpeeled.
		Pounds.	*Pounds.*	*Pounds.*	*Pounds.*	*Pounds.*
1	Tamarack, winter cut	10.3	10.9	0.6	41.8	41.4
2	.....do	9.8	10.6	.8	41.8	41.4
3	.....do	9.1	9.8	.7	41.8	41.4
15	.....do	10.2	10.9	.7	41.1	41.4
16	.....do	10.7	11.0	.3	41.1	41.4
4	Hemlock, winter cut	8.5	9.3	.8	36.8	40.9
5	.....do	8.1	9.8	1.7	36.8	40.9
6	.....do	9.4	12.7	3.3	36.8	40.9
10	Hemlock, June cut	13.3	18.2	4.9	33.5	34.4
10	Hemlock, November cut	11.3	14.8	3.5	37.0	40.9
11	Hemlock, July cut	14.1	16.1	2.0	33.8	34.8
11	Hemlock (peeled, December cut; unpeeled, January cut)	8.5	12.8	4.3	37.9	40.9
12	Hemlock, September cut	9.1	14.6	5.5	35.1	40.0
12	Hemlock, October cut	9.7	12.1	2.4	36.5	37.8
12	Hemlock, January cut	8.3	14.9	6.6	36.8	40.9
13	Hemlock, August cut	10.2	15.0	4.8	33.9	34.8
14	Hemlock, January cut	11.2	12.3	1.1	36.8	40.9

In every instance the ties that were seasoned with the bark show an increased absorption over ties of the same class which had been peeled before seasoning. Despite the fact that in most cases the unpeeled ties have a slightly greater moisture content than the peeled ties, the experiment shows that the difference between the absorptive qualities of the two classes of timber is great enough to overcome the tendency of the drier wood to absorb the preservative more readily.

[a] Throughout this report the ties which were peeled before seasoning will be called "peeled" ties, as distinguished from "unpeeled" ties, or those which had been seasoned with the bark on and peeled immediately before treatment.

The difference in the absorption for hemlock ties of the two classes varies from 0.8 of a pound per cubic foot to 6.6 pounds, a total difference of nearly 6 pounds. This difference is much wider than in the case of tamarack. Indeed, in tamarack it is so slight that it matters little whether or not these ties are peeled before seasoning.

It is plain that the bark should be allowed to remain on the hemlock ties during seasoning. This is opposed to experience with other species, and may be explained as due to casehardening, which takes place when the moist wood under the bark is suddenly exposed to the direct action of sun and wind. The shrinking and hardening of the fibers tend to form a comparatively impervious layer over the surface of the tie, which considerably retards the penetration of the preservative.

Two results are to be drawn from these considerations:

First. It is immaterial whether tamarack ties are peeled before or after seasoning. It has already been stated, however, that to peel before seasoning necessitates extra expense, and it is therefore recommended that the peeling of the ties be deferred until they are being prepared for treatment.

Second. That all hemlock ties should be seasoned without removing the bark.

With ties designed for treatment during the winter months an exception to the above conclusions must be made. The low temperatures prevailing at that time cause the bark to adhere firmly to the wood, rendering its removal difficult and costly. Hence it is recommended that a sufficient number of ties be peeled during the summer to afford a supply for winter use.

THE EFFECT OF IMMERSION IN WATER BEFORE SEASONING.

By immersing freshly cut timber in water for a sufficient period a considerable portion of the sap is leached out, and the cell walls are left in a more porous condition. Hence it might be expected that not only would the subsequent seasoning on exposure to the air be more rapid, but that a more abundant absorption of the preservative would take place during treatment.

Some of the hemlock ties cut from June to September, inclusive, were soaked in water for varying lengths of time. On subsequent exposure to the air it was found that the rate of seasoning was no more rapid than that shown by the unsoaked ties, and that because of the water absorbed during the immersion they failed to reach as low a moisture content. The soaked ties were contrasted with peeled unsoaked ties of the same class to show the influence on the absorption of preservatives. The results are shown in Table 10.

TABLE 10.—*Effect of soaking hemlock before seasoning.*

[Pounds per cubic foot.]

Run No.	When cut.	Absorption.		Difference in favor of soaked.	Weight before treatment.	
		Peeled.	Soaked.		Peeled.	Soaked.
		Pounds.	*Pounds.*	*Pounds.*	*Pounds.*	*Pounds.*
10	June	13.3	14.1	0.8	33.5	33.8
13	June	12.9	11.8	−1.1	33.7	33.8
13	July		12.5	−0.4		
13	August	10.2	11.9	1.7	33.9	36.5
13	September	11.6	12.5	0.9	35.1	36.5

In every instance the soaked ties failed to reach as low a weight per cubic foot as did those which had not been soaked, yet they absorbed slightly more of the solution per cubic foot than did the unsoaked ties. However, this difference in the absorption is so slight that the extra expense is not justified.

THE EFFECT OF STEAMING FOR DIFFERENT LENGTHS OF TIME.

To test this point several loads of each species were treated after being steamed for varying periods. In the accompanying table the ties of each species were divided into two groups in order that the comparison should include only ties of the same class. The vacuum was constant in all the runs. As the lengths of the time of pressure varied in some of the runs, gauge readings were taken at ten-minute intervals, and by comparing the absorption shown by these readings with the known cubic volume of the timber the rate of absorption per cubic foot was obtained. The results are shown in Table 11.

TABLE 11.—*Effect of steaming for different lengths of time.*

[Absorption per cubic foot of timber.]

Length of pressure.	Tamarack.					Hemlock.				
	Group 1.			Group 2.		Group 1.			Group 2.	
	5 hours steam.	3 hours steam.	1 hour steam.	2 hours steam.	1 hour steam.	5 hours steam.	3 hours steam.	1 hour steam.	3 hours steam.	1 hour steam.
	Run 1.	Run 2.	Run 3.	Run 15.	Run 16.	Run 4.	Run 5.	Run 6.	Run 10.	Run 11.
Minutes.	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*
10	5.5	4.2	4.4	4.5	7.4	5.9	5.8	4.2	5.7	4.3
20	8.6	8.1	6.2	6.4	8.4	8.5	6.6	5.9	7.6	5.6
30	10.0	9.7	7.1	7.3	9.3	10.2	8.3	6.7	9.5	7.5
40	10.8	10.7	7.6	7.3	9.7	11.5	9.8	7.2	10.0	8.1
50	11.5	11.4	8.3	8.2	11.2	12.4	10.3	7.9	10.4	9.4
60	12.0	12.0	8.8	9.1	12.1	12.7	10.8	8.4	11.4	11.8
70	12.4	12.7	9.7	10.0	12.1	.....	11.6	8.6	11.8	11.8
80	13.8	13.4	12.0	10.9	12.1	.....	12.1	8.9	12.3	11.8
90	.....	13.6	12.1	10.9	12.1	.....	12.4	9.3	13.3	11.8
100	.....	.....	12.2	11.5	13.0	.....	12.8	9.8	13.8	13.2
110	.....	.....	12.2	11.8	13.0	.....	.....	10.1	14.2	13.2
120	.....	.....	12.3	12.7	13.4	.....	.....	10.4	14.2	13.2
130	.....	.....	.....	13.6	14.0	.....	.....	11.0	14.2	14.1
140	.....	.....	.....	13.6	14.5	.....	.....	11.6	14.2	14.1
150	.....	.....	.....	13.6	14.5	.....	.....	12.0	14.2	14.5
160	.....	.....	.....	14.5	14.9	.....	.....	12.3	15.2	15.6
170	.....	.....	.....	14.5	14.9	.....	.....	12.3	15.2	16.0
180	.....	.....	.....	14.5	15.3	.....	.....	12.6	16.1	16.0
190	.....	.....	.....	14.5	15.3	.....	.....	.....	16.1	16.0
200	.....	.....	.....	.....	15.8	.....	.....	.....	.....	.....

The absorption was found to be too variable to permit of definite conclusions. Group 1 of the tamarack ties shows a distinct tendency for the absorption to decrease with the decrease of the steaming period. This, however, is contradicted in group 2, which was composed of ties similar to those in group 1, the only reason for its separation being that it contained a slightly smaller number of ties which had been seasoned without removing the bark.

In the hemlock ties the absorption in group 1 also shows a tendency to decrease with the decrease of the steaming period, although it appears that the difference in the rate of the absorption can be compensated by prolonging the pressure. In group 2 the absorption was at first greater in the case of the three-hour ties, but soon fell off, indicating that the action of the steam was confined to an external layer, which soon became saturated.

Although the experimental runs failed to produce conclusive data, they indicate that one hour's steaming is too short and that three hours is too long. Therefore, the present custom of steaming for two hours should not be altered, and the pressure should be maintained as long as is warranted by the rate at which the solution is being absorbed. Steaming is decidedly more expensive than the application of pressure, and whenever possible the latter should be substituted for it.

THE EFFECT OF THE SEASON OF CUTTING.

It is popularly supposed that summer-cut hemlock ties do not absorb the preservative as readily as do those cut in fall or winter. This was tested by means of several tramloads of hemlock ties cut in the summer, fall, and winter of 1905. The results of these tests are shown in Table 12.

TABLE 12.—*Effect of the season of the year in which hemlock timber is cut.*

Run No.	Season of cutting.	Average absorption per cubic foot.	
		Peeled.	Unpeeled.
		Pounds.	*Pounds.*
10	Summer	13.3	18.2
	Fall	11.3	14.8
	Winter	10.7	.....
11	Summer	13.4	16.1
	Fall	9.4	.....
	Winter	8.5	12.8
12	Summer	12.1	.....
	Fall	9.4	13.4
	Winter	7.6	14.9

In all three runs the peeled ties show a uniform decrease in the absorption per cubic foot from summer to winter. With one exception, the same rule holds with the ties which were seasoned without removing the bark. There is a possibility, of course, that the decrease in absorption from summer to winter may be partially due to a change in the wood structure. The probability, however, is in favor of the effect of climatic conditions upon seasoning. This view is confirmed by comparing the moisture contents of wood cut in each of the seasons in question. Table 13 shows the average weight per cubic foot before treatment for ties cut each month from June to January, inclusive.

The weight per cubic foot is lightest in summer and heaviest in winter, the weight of the fall-cut ties coming between. The strong influence which the moisture content of the wood has upon the absorption of the solution is sufficient to account for the lesser absorption shown by the fall and winter cut ties. Hence it may be assumed that the only effect of the season of cutting upon the absorption is indirect, acting merely through its influence upon the seasoning of the timber.

The popular prejudice against summer-cut ties may be explained by the fact that some of the hemlock ties cut at that season are peeled to obtain their bark for tanning purposes. These ties are therefore subject to casehardening, as a result of which the difficulty of injecting the preservative is considerably increased.

TABLE 13.—*Comparative weights of hemlock ties cut during various months.*

Season of cutting.	Weight per cubic foot before treatment.	
	Peeled.	Unpeeled.
Summer:	*Pounds.*	*Pounds.*
June	33.5	34.4
July	33.8	34.8
August	33.9	36.1
Fall:		
September	35.1	40.0
October	36.5	37.8
November	37.0	.....
Winter:		
December	37.9	.....
January	36.8	40.9

THE COMPARATIVE ABSORPTIVE QUALITIES OF HEMLOCK AND TAMARACK.

To permit of a fair comparison of the absorptive qualities of hemlock and tamarack, each contrasted run was chosen from material cut at the same time and seasoned in a similar manner. Both had reached as low a moisture content as was practicable, and both were subjected to the same steaming period. The absorption of the solution was determined by gauge readings at ten-minute intervals, that the comparisons might be based on equal pressure periods.

TABLE 14.—*Showing the comparative absorption of hemlock and tamarack ties.*

[Average of cylinder-loads.]

Absorption per cubic foot.		Difference in favor of tamarack.
Tamarack.	Hemlock.	
Pounds.	*Pounds.*	*Pounds.*
13.4	12.1	1.3
12.2	10.1	2.1
13.8	9.3	4.5
13.0	9.3	3.7
15.3	12.6	2.7

Table 14 shows that in every case tamarack absorbed the greater amount of the preservative, and at least after ordinary seasoning periods is the more easily impregnated of the two species. This may be partially accounted for by the fact that, due to their smaller size, tamarack ties, as a rule, have a greater proportion of sapwood. At any rate, there is too little difference between the two species to necessitate separate methods of treatment, although they should not be included in the same run except where their separation would involve extra labor and expense.

SEASONING AFTER TREATMENT.

The necessity of seasoning ties treated with water solutions before they are laid for use has been discussed in previous bulletins of the Department of Agriculture.[a] The principal objection to the use of soluble salts in wood preservation lies in their tendency to leach out on subsequent exposure to moisture. When the wood is first treated, the cell cavities are filled with the water solution, which, if brought

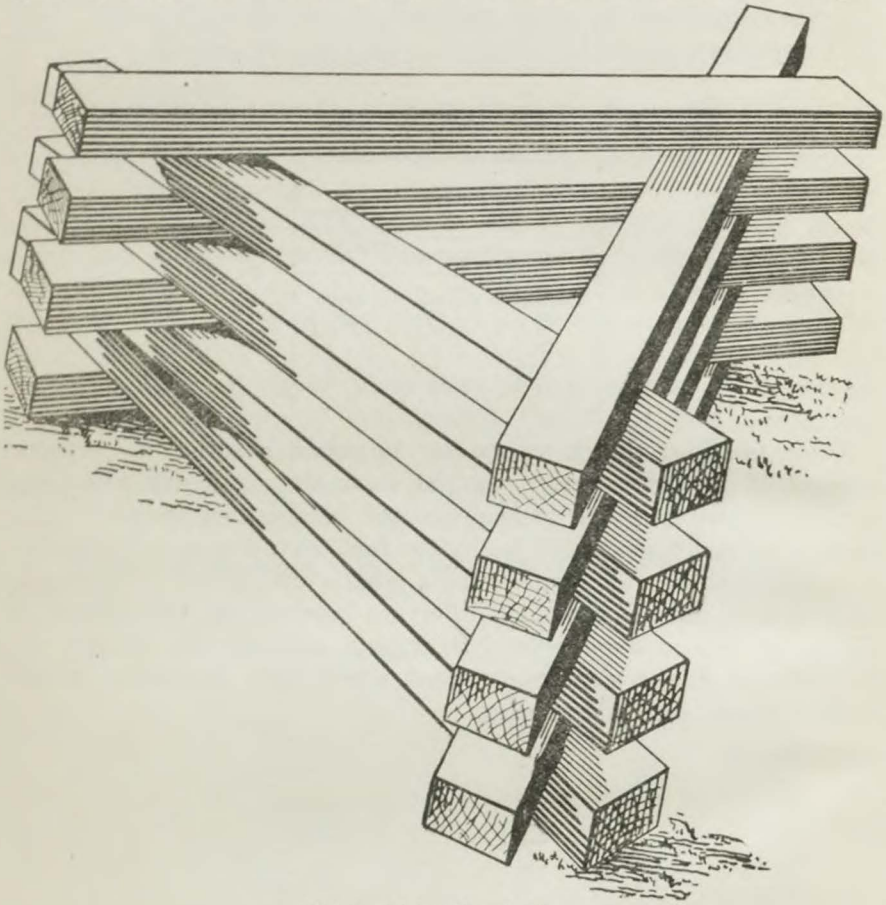

FIG. 4.—A triangular tie pile.

in contact with water in the soil, permits the salt to leach out with great rapidity. If, however, the treated wood is allowed to dry out, the salt is deposited on the cell walls and no leaching can take place as long as it remains in that condition. It is therefore recommended that whenever possible the treated ties should be seasoned before they are placed in the track.

[a] Bulletins 14 of the Bureau of Plant Industry and 41 of the Forest Service.

The length of time required for the seasoning of treated ties must depend primarily upon the season of the year. Ties treated at Escanaba in the latter part of July, 1905, and piled in the yard lost 82 per cent of the water absorbed during the treatment in forty-two days, and in seventy days this percentage had increased to 95. If shipped in open cars spring and summer treated ties will partially season in transit; but even at this season of the year they should be piled along the right of way for at least a month before being placed in the track. Ties shipped immediately after treatment in the late fall and winter lose little moisture en route, and a correspondingly longer period of seasoning should be permitted after they have arrived at their destination.

The common custom of distributing the treated ties on the ground along the right of way should be discouraged. In only a comparatively few cases do the treated ties become seasoned before they are unloaded along the track. There they are brought in direct contact with the moisture in the ground and seasoning is retarded. The form of pile best adapted for piling along the right of way is the triangular form illustrated in figure 4.

The advantages of this form of pile for treated ties along the right of way are:

1. That the maximum rate of seasoning is secured.
2. That no tie is brought in contact with the ground at more than one point.
3. That only a comparatively few ties are required, thus permitting numerous piles along the right of way, with a consequent saving in the labor of carrying the ties from the pile to the track.

RECORDS.

In order that accurate knowledge may be obtained of the service given by the treated ties under different conditions and of the value of the changes and improvements which will be made in the treatments from time to time, it is important that careful records should be kept of the number of years the ties remain in use. This can be arranged without inconvenience by driving a dating nail, with the year stamped in the head, into each tie when it is inserted in the track. These nails should be driven into the upper faces about half way between the rail and the end of the tie. Each section foreman should be instructed to send a monthly statement to the roadmaster in charge, giving the number of treated ties removed from the track, the kind of timber, the year in which the ties had been put in, the treatment received, and the cause of removal. Ties removed from main tracks and from side tracks should be noted on separate sheets.

From these section records an annual record should be prepared for each division. Suggestions for the proper forms of monthly and annual record blanks are given in Bulletin 18 of the American Engineering and Maintenance of Way Association.

CONCLUSION.

It is improbable that a treatment will ever be secured for close-grained hemlock and tamarack which is comparable to that of the more porous species. In treating the less resistant woods with the antiseptic oils the principal objects are to secure a uniform penetration with as small amount as possible of the expensive preservative. But in the impregnation of hemlock and tamarack, especially with a salt solution, the chief problem is to inject the greatest possible amount of the preservative into the timber, and secondarily to diffuse it throughout the interior of the wood.

Including freight and labor charges the cost of the average untreated hemlock or tamarack tie when laid for use west of the Mississippi is estimated (by the Chicago and Northwestern Railway Company) to be about 75 cents. The cost of impregnation with zinc chlorid is about 12 cents per tie, making the cost of the treated tie 87 cents. On the basis of an annual charge computed from the formula $r = \mathrm{R}\frac{1.0p^n 0.0p}{1.0p^n - 1}$ in which r is the annual charge, R the initial expenditure, p the rate of interest, and n the years of the recurring period, the following comparative statistics are derived, using as the basic data the estimated life of an untreated tie as five years, and an interest rate of 4 per cent. Then the annual charge on an untreated tie costing 75 cents is 16.8 cents. For a treated tie costing 87 cents and lasting six years the annual charge is 16.6 cents; lasting seven years, is 14.5 cents; lasting eight years, is 12.8 cents, and ten years, the estimated life of a treated tie, is 10.7 cents. These figures demonstrate that an added life of a single year makes the cost of treatment practicable, and an added life of five years (a conservative estimate) secures a saving of 36.3 per cent in the annual charge. It should thus be borne in mind that, however difficult the absorption of hemlock and tamarack may appear in comparison with that of the porous species, the treatment of these timbers is by no means unsatisfactory and results in a decided economy to both railroads and the forest resources of the country.

RECOMMENDATIONS.

The following recommendations are based upon the results of the experiment:

1. The ties should be transported to the treating plant as early in the spring as possible and piled 7 by 2 to season.

2. No hemlock ties should be treated which weigh more than 40 pounds per cubic foot.

3. No tamarack ties should be treated which weigh more than 42 pounds per cubic foot.

4. Hemlock ties received at the yard before April and piled 7 by 2 will be in a condition to treat by the end of the following summer. If received much later, they should be held over to the summer of the following year.

5. Tamarack ties received in the spring and piled 7 by 2 will be in a condition to treat after three or four months.

6. Though there need be no discrimination against rafted ties, soaking to assist in the subsequent seasoning and treating is not advisable.

7. The ties should not be peeled before seasoning, with the possible exception of those intended for treatment during the winter when peeling is impracticable.

8. There should be sufficient room in the seasoning yard to hold a continuous supply of seasoned ties.

9. It is preferable that hemlock and tamarack ties be treated in separate cylinder loads.

10. For the treatment of air-seasoned hemlock and tamarack two hours' steam should be applied at 20 pounds pressure. During the impregnation with the preservative the pressure should be continued as long as is warranted by the rate of absorption.

11. After treatment the ties should be allowed to season before being laid in the track.

12. Record should be kept of the length of service given by the treated ties.

THE EXPERIMENTAL TRACK.

During the course of the experiment about 6,000 ties had accumulated. These were cut in different months of the year, seasoned in different ways, and treated under varying conditions. It is now proposed to lay these ties in a trial section of track in order to put the different methods of handling, treating, and protecting ties to a practical test. For this purpose a location should be selected that will afford a fair average of the conditions under which most of the treated ties are now being used and where they will be subjected to as little disturbance as possible. It should be easily accessible for

inspection by representatives of the railroad and of the Forest Service. Seasoned and untreated ties such as are in general use in the railroad, as well as some from the regular run of treated ties, should be included with those which have been treated in various ways during the progress of the experiment. Each tie should be numbered with a device similar to a dating nail in order that a careful record may be kept throughout the entire length of its service.

MECHANICAL WEAR AND TEAR.

It should be borne in mind that the impregnation of timber with antiseptics is a protective measure merely against decay and not at all against the mechanical abrasion to which the ties are subjected by the cutting and grinding action of the rails and spikes. Before it can be said that a certain method of chemical treatment will prolong the life of a tie for so many years, it must be granted that the tie will be so protected from abrasion as to prevent its mechanical destruction before the full value of the treatment has been realized. There are many devices for securing this protection, of which the simplest are tie-plates and screw-spikes. Both of these have been fully discussed in previous publications of the Forest Service.[a]

Tie-plates.—Numerous forms of tie-plates are used in this country, many having been employed for several years on ties of oak and other hardwoods. With the substitution of treated ties of softer woods the same types of plates were used, but it was found that they afforded little protection and in many cases the ties so equipped were destroyed more rapidly than where no such device was used. An investigation showed that in every case the destruction was caused by projections from the under surface of the plates, such as spines or flanges. When used in hardwoods the spines become firmly embedded in the tough fibers of the wood and the plates thus give excellent service, but the fibers of the softer woods are too weak to resist the pulling action of the rails. The spines become loosened from the ties and by the constant motion of passing trains they grind the fiber and actually assist in the destruction of the tie. Water collects in the holes under the plates, the antiseptic salts in the treated ties are leached out, and the development of wood-destroying fungi is promoted. For these and other reasons more fully discussed in the publications referred to above, it is recommended that the spiked tie-plates now used by the Chicago and Northwestern Railway should be abandoned, with the substitution of some form better adapted to the demands of the ties in use.

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[a] Bulletin 50. Cross-Tie Forms and Rail-Fastenings, with Special Reference to Treated Timbers.

Circular 46. Holding Force of Railroad Spikes in Wooden Ties.

Spikes.—Second in importance only to rail cutting is the mechanical injury resulting from the form of spike generally used by the railroads in the United States. Even in the case of hardwoods much injury results from the tearing action of this type of spike, but the deterioration is hastened in soft wood ties which allow the spike to loosen much more readily. This not only necessitates frequent redriving, but permits the abrasion of the fibers under the base of the rail. The destruction is increased in the case of treated ties in which any abrasion of the treated surface exposes the unprotected wood to fungous attack.

In the experimental track it is proposed to test tie-plates of various patterns. These will consist of metal and of creosoted wood. In all cases in which wooden tie-plates are used screw-spikes will be employed for fastening the rail to the tie, and with the metal plates both screw-spikes and ordinary spikes will be used.

The experimental track should be maintained permanently for testing representative ties treated by different processes and by variations of the same process and further for determining the practical value of any device to promote the economical maintenance of the roadbed.

Approved:

JAMES WILSON,
Secretary of Agriculture.

WASHINGTON, D. C., *October 29, 1907.*

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